A Novel Proactive Routing and Service Discovery Scheme for Mobile Ad Hoc Networks

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***Abstract*-We present a reliable solution for service data exchange provided by various nodes of a wireless ad-hoc networks without bothering the routing protocol mechanism. The service is defined as the entity invoked either by software, a host or a user. In recent works, the mechanism of service-discovery has been already implemented at application layer. The main idea of this work is to implement a new service discovery mechanism at the network layer without disturbing the routing protocol machine in order to cut down latency and energy consumption.**

Keywords-Component; Ad-hoc Network; Routing Protocol; Service Discovery Mechanism; Performance Evaluation

I. INTRODUCTION

A Mobile Ad-hoc Network (MANETs) is a collection of autonomous nodes or terminals that communicate together using a multi-hop message routing while maintaining decentralized connectivity. The nodes can move and their network topology may be temporal. Each node acts as a transmitter, receiver and router. In such network, there is no centralized administration. Each node can join the network or disappear at any time.

The MANET networks have recently focused a lot of attention on research studies and many applications have been set up. In this paper we focus on the issue of service discovery mechanism. The service discovery mechanism is a type of applications used to detect a service that allows a machine to use it remotely. The service is defined as hardware, or software implemented with a host that can be used by a person or another host in the network.

In recent works, many solutions have been proposed in this context: Service Location Protocol [1], JINI [2], Universal Description and Integration (UDDI) [3] etc... These proposals are not valid for this type of network because they do not take into account the mobility of nodes, and they introduce a large message traffic that the ad-hoc network cannot support.

To overcome this problem, other solutions such as GSD [4], Konark [5], DEAPspace [6] and GSR [7] have been proposed. These protocols meet this need but in a higher level than the routing layer.

Our aim is therefore to implement this mechanism in the routing level of the OSI model. The solution suggested at this level [8] is to define a new message SDM (Service Discovery Message) in the routing protocol. This solution is more reliable in the sense that it increases the number of control messages exchanged. So we thought to incorporate this message in other periodically exchanged messages.

The main contribution of this paper is as follows. We choose as routing protocol OLSR that uses two types of periodic messages: Hello messages for neighborhood detection and TC messages to topology control. Furthermore, we integrate the service discovery message with periodic TC message and thus we demonstrate that we can use the maximum of services using the minimum of the messages exchanged.

The rest of the paper is organized as follows. The next section discusses the state-of-the-art which integrates the service discovery in wireless MANET network. Sections III and IV describe the details of the existing routing protocol and our approach to service discovery. Our implementation and its evaluation results are described in Section V. And, finally, conclusions are drawn in section VI.

II. OPTIMIZED LINK STATE ROUTING OLSR

OLSR [9] is a proactive routing protocol. As its name means, OLSR presents an optimizing link state routing. Its idea is based on electing a partial neighborhood node as multipoint relay (MPR Multi-Point Relay) to broadcast packets. The MPRs are chosen so as to reach the two hops neighborhood. Based on this concept, all nodes in the network are attained with a reduced number of broadcast traffic control messages.

To maintain routing neighborhood tables, OLSR uses two types of messages periodically exchanged between the nodes: the message "HELLO" and "TC" (Topology Control). Each node broadcasts periodically and locally (in its routing zone) Hello messages containing information about its neighborhood and link state. These messages allow each node to know its immediate neighborhood and the state of the direct links. So a set of MPR is elected, therefore we can cover the two hops neighborhood. The second type of messages known as TC messages is used to build the necessary routing tables. Only nodes elected as MPR generate and rebroadcast these messages to avoid flooding. Upon receipt of TC messages, a network graph can be constructed. Based on this graph, each node can calculate its routing table that enables it to reach any destination in the network.

III. RELATED WORK

Many works have been conducted within the integration of service discovery mechanism in mobile ad hoc networks. We can distinguish two research efforts fields: the first group of the own service discovery protocols and the second group for those who integrate this mechanism with protocols already present or use the cross layering.

We present for example SLP service Location protocol [10] that provides a scalable mechanism for discovery and localization of network services. Another protocol is Simple

Service Discovery Protocol SSDP [11] This protocol provides a mechanism with which any client of the network can discover network services with a static configuration, The UDDI [3] (Universal Description, Discovery and Integration) is an XML-based and specially designed for Web services. It provides the Web service discovery. We mention also, Universal Plug and Play (UPnP) [12] which is a Microsoft standard, providing automatic discovery of computer's components and services, but it includes many security vulnerabilities. A novel Group based Service Discovery Protocol for MANETS is based on the concepts of peer-to-peer caching of advertisements, whose services have been discussed in GSD [4].

Jini[2] is a network architecture for building distributed systems in the form of services cooperating modules.

These proposals are not valid for this type of networks because they do not take into account the mobility of nodes. Also, they introduce a large traffic message that the ad hoc network cannot support.

To solve this problem, Konark[5] is introduced which is a service discovery and delivery protocol for Ad-Hoc networks. For service discovery, Konark uses a distributed peer-to-peer mechanism that provides a mechanism to allow a device to advertise and discover services in the network. Konark is XML-Based.

In [12], the authors present a Routing scheme called SFUSP (Self Eliminating Fault Tolerance Based Uninterrupted Reliable Service Switching Mobile Protocol) who use a clustering and comparison techniques to find node's services.

Ververidis and Polyzos, present in [13], a novel hybrid service and route discovery protocol called AVERT (Adaptive SerVicE and Route Discovery ProTocol for MANETs).

Now we address the example that incorporates services discovery mechanism with OLSR protocol. In [7], the authors proposed an SDM message (Service discovery message) exchanged with the OLSR control message. This idea will generate a new type of message with more bandwidth and energy consumption. We have used this concept to integrate this novel type of message with Topology Control message and also no degradation towards a classic OLSR.

Most of the presented works develop new designations of services discovery mechanisms, or uses other types of messages which lead to the waste of bandwidth and Energy. We present a novel mechanism that disturbs services information with existing exchanged messages.

IV. IMPLEMENTING SERVICE DISCVERY MECANSIM UNDER OLSR

A key feature of ad-hoc networks is the mobility of nodes that compose them. Connectivity varies with time due to the destruction of radio links generated by the move of terminals. All these reasons make it essential to use an efficient routing protocol.

Service discovery plays an important role in these wireless communication systems. A real-time response and less consumption is the main goal of efficient service discovery systems in MANET network. Indeed, the MANET's terminals operate with a limited energy and bandwidth. These factors complicate the implementation of an efficient mechanism in order not to consume the resources and have idea about the maximum of services in the network. Our solution has therefore to address these challenges.

A. *Service Discovery and Topology Control Message*

The Fig.1 shows the SDM message format. Five fields form this message of 8 bytes. The type field indicates the type of message if it is a service announcement (Type = 1) or requested service (Type = 2). An announcement of service, on one hand, is sent to declare a local service to the entire network. On the other hand, when a node wants to access a service and that service is not registered in its memory, it sends a request of service, specifying the name and the characteristics of the requested service.

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
|     Type      | Service Name |SDM_Interval |  Life Time       |
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
|                     Service Description                       |
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Figure 1. Service discovery message format

The Service Name field shows the name of the advertised or asked service. The number of declared services could reach 256, as this field is encoded to 8 bits. The third field, SDM_INTERVAL, defines the life time of the message to limit the traffic in the network. If this field is expired, the message will be automatically removed from the network. Lifetime indicates the length of time of service availability (not the life time of the message). This period is a maximum of 256 seconds. In case the service is available over this period, another message updated is rebroadcast. Service Description field describes the characteristics of service advertised. This field has 4 bytes to describe the details of the service that will be useful to other nodes since they decide according to these characteristics, to use the service or not. For example if the service provided is a printer, this field describes its characteristic i.e. color or black and white printer, with scanner or not etc...

Now, we show the format of the TC message according to RFC 3626(fig. 2). This TC message is comprised by three fields Advertised Neighbor Sequence Number (ANSN), a reserved field and Advertised Neighbor Main Address. The second field is reserved and MUST be set to "0000000000000000". The third field (Advertised Neighbor Main Address) contains the main address of a neighbor node. All main addresses of the advertised neighbors of the Originator node are put in the TC message. If the maximum allow that message size (as imposed by the network) is reached while there are still advertised neighbor addresses which have not been inserted into the TC-message, more TC messages will be used until the entire advertised neighbor set has been sent. TC messages are broadcasted and retransmitted only by the MPRs in order to diffuse the messages in the entire network and to reduce the number of broadcast. In our proposition, the SDM messages are put in TC message before the set of all advertised main addresses for not affecting the original TC message, and comply with the real-time constraints.

Fig. 3 shows the resulting message, consisting of two types of messages, message and TC service discovery message.

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            ANSN               |           Reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Advertised Neighbor Main Address                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Advertised Neighbor Main Address                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             ...                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2. TC message format [9]

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            ANSN               |           Reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type     | Service Name |SDM_Interval |  Life Time        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Service Description                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Advertised Neighbor Main Address                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Advertised Neighbor Main Address                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             ...                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3. TC-SD message format

B. *Service Discovery Algorithm*

When any node has a service and wants to declare it in the network, it analyzes the service table to decide whether announce this service or not. The node decides to announce a service, if not declared by another node with the same characteristics, in order to avoid redundancy. The declaration of a service is made according to the algorithm presented in Fig. 4.

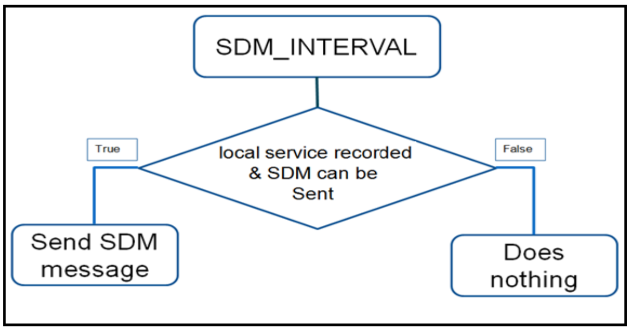

Figure 4. Service announcement Algorithm

This announcement will be received by all nodes constituting the network.

Algorithm: Send SDM Message

If (CURRENT_TIME < FIRST_SDM_SENT_INSTANT+ SDM_INTERVAL) *then*
    If(CURRENT_SDM_RECORDED && SERVICE_CAN_BE_SENT) *then*
        SEND_SDM_MESSAGE
    End if
End if

A node that receives this message and who already has this service, deletes this message without the replay given to other nodes in order to limit the redundancy of the message as shown in algorithm presented in Fig. 5.

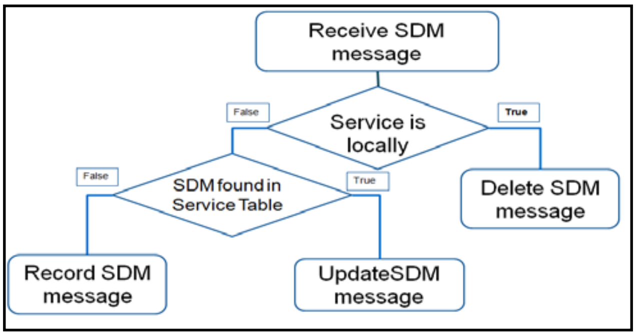

Figure 5. Service received Algorithm

Otherwise, after receiving the message, it consults its table service, seeking the key corresponding to the net address of source of the message, if the list associated with this key contains this service, therefore, the node compares the lifetime of the two services and saves the one with the greatest lifetime.

Algorithm: Receive SDM Message

If (SDM_MESSAGE_IS_LOCALLY) *then*
    If (SDM_MESSAGE $\in$ SERVICE_TABLE)
        Update SDM entry
    Else
        Record the new SDM
    End if
Else
    Delete SDM message
End if

If the node does not find the address to the source of the message, then it adds another column in the table corresponding to this new provider.

After receiving any service with the previous algorithm, if this service is available, then the node will advertise this SDM to its neighborhood with TC message, according to the declaration algorithm presented in Fig. 4.

V. RESULTS

In this section we analyze the energy consumption model, and we illustrate simulation parameters and show the JIST/SWANS [19] simulation's results. Thus, we demonstrate the non-degradation compared with the classical OLSR.

A. *Analytics Results:*

Using the IEEE802.11 [15] standard with data rate equal to 54 Mbps, if we consider the energy model used in [16], the energy used by any node to transmit a packet is given by the following equation:

$$E(p,ni) = P(p,ni) * t_p = i * v * t_p \qquad (1)$$

$\mathrm{P(p,ni)}$ is the power to transmit a packet p by any node ni, v is the node battery voltage and, i is the current (in Ampere).

$\mathrm{i * v}$ is the constant party of the equation and dependent on the technical characteristic of the host. Using [17] and [18], the time taken to transmit the packet p (in sec) is presented by (2):

$$t_p = \frac{p_h}{6*10^6} + \frac{p_d}{54*10^6} \quad (2)$$

The number of bits of the packet header is presented by p_h and p_d is the payload presented in [17] by the following formula:

$$p_d = 256\big(\ 228(data) +\ 8(UDP) +\ 20(IP)\big) \quad (3)$$

The length of the SDM message is 4 bytes. Then the time added to transmit a SDM message is:

$$t_{ps} = \frac{4*8}{54*10^6} \approx 10^{-6}\ seconds \quad (4)$$

According to (1), we note that our solutions add to the equation of energy negligible fold increase compared to the first solution which introduces another type of message with another quantity of energy and bandwidth consumed. And it is even better than the solutions that define a new service discovery protocol.

Comparing our results to those presented by J. L. Jodra, M. Vara, J. M. Cabero and J. Bagazgoitia [8], we find that our solution reduces the transmission time by a half because the first solution uses 4 bytes in the SDM header.

Although, in the tables [8] showing the number of messages exchanged, the authors then add 2345 additional messages for SDM other than 127627 TC messages. So for large number of TC messages, we declare that the network services in 2345. In our proposal, the number of messages SDM services is equal to the number of TC message. We win on the network overhead and we sent more services, as the single message exchange is TC messages SDM. We present afterwards that this modification of TC message does not affect the performances of our protocol.

B. Simulations Results of SD-OLSR

1) Performances Metrics:

The following metrics are used to evaluate the performances of our protocols [14]:

- **Routing Overhead:** this metric is most needed in Ad Hoc network simulations. We found several definitions of this metric according to the parameters, set of simulations. We chose the one that measures the overhead of network control messages. It is equal to the number of controlled messages broadcasted in the network divided by the sum of number and by the number of data messages sent.
- **Packets delivery ratio:** it's a very important metric that measures the percentage of packets received. It is equals to the number of packets received divided by the number of packets sent. This metric allows us to measure what level the routing protocol can support data packets.
- **End-to-End Delay** [6]: This metric measures the average over all duration elapsed by the data packets to reach destination. It is equal to the average of differences between moments of sending and reception of data packets.

2) Routing Overhead:

To present the impacts of our proposed solution, we perform simulations with the JIST\SWANS [19] simulator. We present, firstly, routing overhead that shows the number of control messages sent, divided by the sum of the number of control messages and data sent. This metric show the effect of adding the message in the messages SDM TC traffic control in the network.

Fig. 6 shows the routing overhead according to the number of the node forming the network, in a square simulation space of 1000 meters. The duration of the simulation is 5 minutes.

According to this Figure, we note there is no difference between the two curves with or without SDM message. With little variation due to the volume of TC message "Topology Control" that contains the SDM. This small change in the overhead shows the advantage of our solution compared to the second traditional solution.

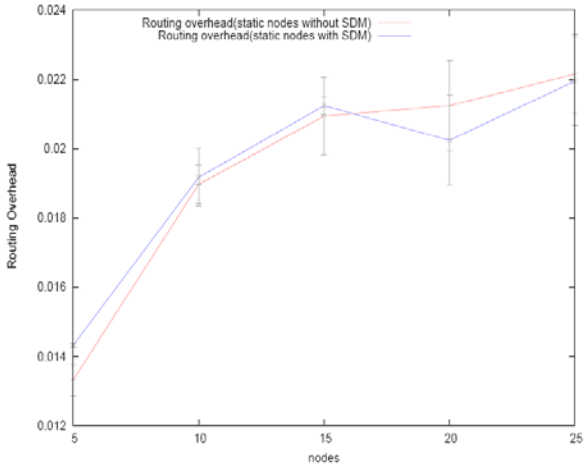

Figure 6. Routing overhead (statics nodes)

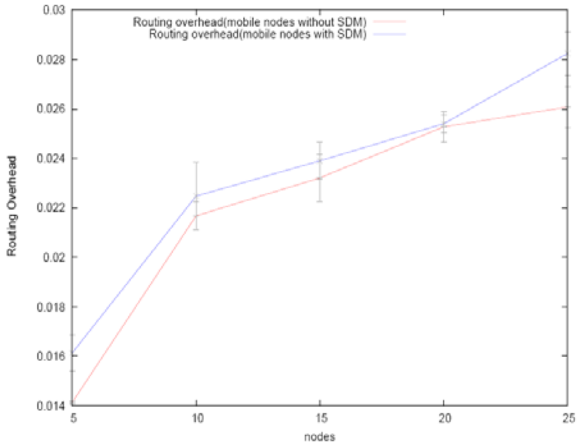

Figure 7. Routing overhead (mobiles nodes)

The result of this latter solution is shown in [8]. We note more that the number of hello and TC messages sent, there was the number of SDM messages exchanged, however in the context of our solution; we send only two types of TC-SD and Hello messages.

We also compare the two versions of OLSR in a mobile environment with the random waypoint mobility model in Fig.7.

With this mobility model, a node begins by remaining steady for some instants, and then it moves to a random chosen destination with a random speed (m / s) belonging to the interval [SPEED_MIN, SPEED_DMAX]. After arrival, the

node stands still and then resumes the process of finding the random destination and speed.

So we can note the insignificant effect of service discovery message on the routing overhead and the significant impact that brings to an ad hoc network.

3) Packets Delivery Ratio:

We present in Fig. 8, the fraction of the number of data messages received by the number of messages sent.

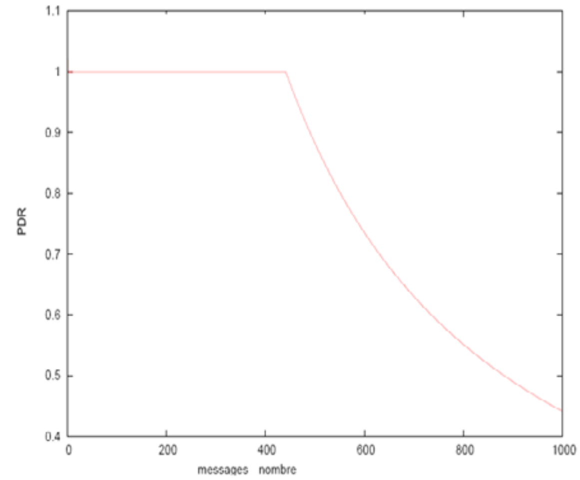

Figure 8. Packets delivery ratio (PDR)

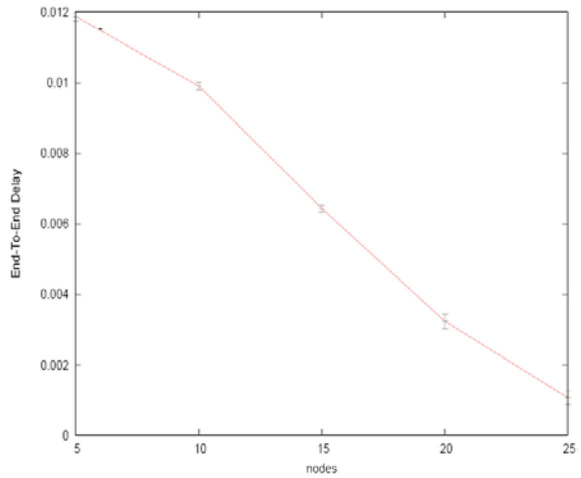

Figure 9. End-To-End delay (Static Nodes)

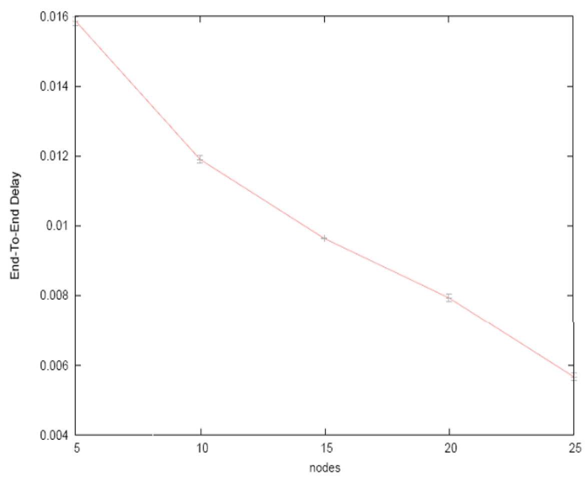

Figure 10. End-To-End delay (Mobiles Nodes)

The curve obtained shows a straight line parallel to the axis of number of messages less than 441 which then begins to decline. This variation shows that if the number of messages is low, the sent packets will be received automatically (if the channel loss is negligible).

From a fixed number of packets, the physical layer will be saturated with these messages, which reduce the PDR.

1) The End-to-End Delay:

This parameter shows the average time taken by data messages to reach a destination from a source in the network. We note that the curve (Fig. 9) decreases with the number of fixed nodes. In fact, in the case of a less dense network, to reach the destination, a packet must cross a fairly long path. However, in a dense network, which has several paths, we can choose the shortest.

In Fig. 10 we represent the case of mobile nodes. This variation shows that in the case of mobility, the time taken by the packets increases with the number of nodes and this is due to the phenomenon of breaking link.

This makes the arrival of packets a bit later. For example, if a packet reached a node z, from a node x through another node y, when it arrived at this node (node y) and the link y-z, therefore, will be broken, there will be an additional delay added by them to find another path to z.

VI. CONCLUSION:

In this paper, our objective was to develop a mechanism of service discovery in ad hoc networks over a proactive routing protocol. The service discovery presents a great challenge in this type of networks because it is characterized by a decentralized infrastructure, limited sources and mobility of these components. We proposed a solution that consists of integrating service discovery message (SDM) in the TC message in OLSR protocol. The SDM message will be broadcasted with the TC message over all nodes of the network to declare or request a service. We have also shown that this mechanism is efficient in the sense that each node will use a range of services available in the network with low cost.

Our future work on SD-OLSR tackles with infect, security authentication mechanisms and encryption must be implemented to protect against attacks that aim to spying on the network or disrupt its operation by disseminating misinformation for example. The integrity must be ensured by strengthening the safety of services provided by the networks.

REFERENCES

[1] E. Guttman, C. Perkins, J. Veizades and M. Day, “Service Location Protocol, Version 2”, RFC 2608.

[2] K. Edwards and T. Rodden, “Jini example by example”, Prentice Hall PTR”, NJ, USA, 2001.

[3] UDDI’s official webpage, http://www.uddi.org.

[4] D. Chakraborty, A. Joshi, Y. Yesha and T. Finin, “GSD: A novel Group based Service Discovery Protocol for MANETS”, WCNN, 2002.

[5] S. Helal, N. Desaii, V.Verma and C. Lee, “Konark: A Service Discovery and Delivery Protocol for Ad-Hoc Networks”, WCNC, 2003.

[6] R. Hermann, D. Husemann, M. Moser, M. Nidd, C. Rohner and A. Schade, “DEAPspace: Transient ad hoc networking of pervasive devices”, Computer Networks, 2001.

[7] D. Chakraborty, A. Joshi and Y. Yesha, “Integrating Service Discovery with Routing and Session Management for Ad-hoc Networks”, Journal Ad Hoc network, 2006.

[8] J. L. Jodra, M. Vara, J. M. Cabero and J. Bagazgoitia, "Service Discovery Mechanism Over OLSR for Mobile Ad-hoc Networks" , AINA'06 , 2006.

[9] T. Clausen, and P. Jacquet, "Optimized Link State Routing Protocol (OLSR)", Draft IETF RFC 3626, 2003.

[10] E. Guttman, C. Perkins, J. Veizades, and M. Day, "Service Location Protocol", Version 2, Draft IEFT RFC 2608, 1999.

[11] T. Cai, P. Leach, Y. Gu, Y. Y. Goland, and S. Albright, "Simple Service Discovery Protocol", IETF Internet Draft, April 1999, work in progress.

[12] UPnP's offical webpage, http://www.upnp.org.

[13] R.S. Shaji, R.S. Rajesh, B. Ramakrishnan and F. Rajesh, "A Novel Routing and Service Migration Scheme for Communication among Heterogeneous Devices in Pervasive Environment", ICCCET 2011, March, 2011.

[14] C.N.Ververidis and G.C.Polyzos, "AVERT: Adaptive SerVicE and Route Discovery ProTocol for MANETs", WIMOB '08. IEEE 2008.

[15] Wang, S. and Z. Qiu," A link type aware routing metric for wireless mesh networks", proceeding of the 8th International Conference on Signal Processing, 2006.

[16] IEEE802.11 standard, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications", 1997.

[17] D.R.Floriano and F. Marco, "Energy Efficient OLSR Performance Evaluation under Energy aware Metrics", SPECTS, 2009.

[18] L. M. Feeney and M. Nilsson, "Investigating the energy consumption of a wireless network interface in an ad hoc networking environment", INFOCOM, 2001.

[19] G.David and M.Narayan, "Power Control for Wireless Data", IEEE Personal Communications , April 2000.

[20] R. Barr and Z. J. Haas, "JiST/SWANS homepage", http:// jist. ece. cornell.edu/, 2005.

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